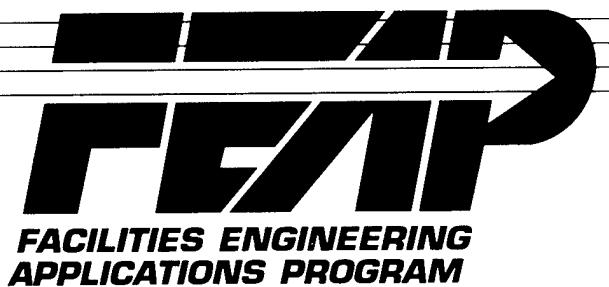


FEAP-UG-99/97  
December 1999



USER  
GUIDE

# User Guide and Specifications for Using Blastox® To Remove and Stabilize Lead-Based Paint

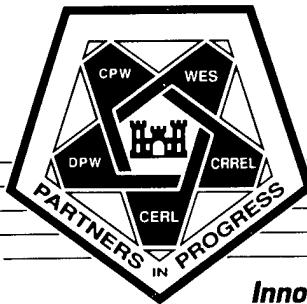
by

Vincent F. Hock and Susan A. Drozdz  
U.S. Army Engineer Research and Development Center  
Construction Engineering Research Laboratory  
Champaign, IL 61826-9005

Malcolm E. McLeod and Charles W. Racine  
U.S. Army Corps of Engineers  
20 Massachusetts Avenue, NW  
Washington, DC 20314-1000

*Approved for Public Release; Distribution is Unlimited.*

20000424 142



U.S. Army Center Public Works  
Alexandria, VA 22315-3862

*Innovative Ideas for the Operation, Maintenance, & Repair of Army Facilities*

The contents of this report are not to be used for advertising, publication, or promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. The findings of this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

***DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED***

***DO NOT RETURN IT TO THE ORIGINATOR***

# REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

|   |  |   |   |
|---|--|---|---|
| 1. AGENCY USE ONLY (Leave Blank)  | 2. REPORT DATE   | 3. REPORT TYPE AND DATES COVERED                        |   |
|   | December 1999  | Final   |   |
| 4. TITLE AND SUBTITLE<br>User Guide and Specifications for Using Blastox® To Remove and Stabilize Lead-Based Paint  |  |   | 5. FUNDING NUMBERS<br>FEAP<br>M3-FE3; FEAP-M3-F83/F74     |
| 6. AUTHOR(S)<br>Vincent F. Hock, Susan A. Drozdz, Malcolm E. McLeod, and Charles W. Racine  |  |   |   |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>U.S. Army Construction Engineering Research Laboratory (CERL)<br>P.O. Box 9005<br>Champaign, IL 61826-9005  |  |   | 8. PERFORMING ORGANIZATION REPORT NUMBER<br>FEAP UG 99/97 |
| 9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)<br>U.S. Army Corps of Engineers<br>ATTN: CEMP-RI<br>20 Massachusetts Avenue, NW<br>Washington, DC 20314-1000  |  |   | 10. SPONSORING / MONITORING AGENCY REPORT NUMBER          |
| 9. SUPPLEMENTARY NOTES<br>Copies are available from the National Technical Information Service, 5385 Port Royal Road, Springfield, VA 22161.  |  |   |   |
| 12a. DISTRIBUTION / AVAILABILITY STATEMENT<br>Approved for public release; distribution is unlimited.   |  | 12b. DISTRIBUTION CODE                                  |   |
| 13. ABSTRACT (Maximum 200 words)<br>The U.S. Army maintains a large inventory of buildings constructed before 1978, when the use of lead-based paint (LBP) was discontinued. The Army also owns more than 300 elevated water storage tanks and hundred of other steel structures that have been painted with red lead primers. Regardless of whether LBP has been applied to a substrate of steel or wood, LBP abatement and disposal is problematic. A recently developed proprietary product—Blastox®—consists of a material, which, its manufacturer's product literature claims, may be added at a 15 weight percent mixture to a typical abrasive medium to create an engineered abrasive suitable for sand-blasting lead-coating system from wood, steel, or concrete surfaces. The manufacturer also maintains that the additive chemically stabilizes the lead rendering the waste product nonhazardous.<br><br>CERL's laboratory and field evaluations confirmed the feasibility of removing and stabilizing LBP in a one-step process. Abrasive blasting successfully removed the paint and the lead stabilizer immobilized the lead, allowing the waste to pass Environmental Protection Agency tests. |  |   |   |
| 14. SUBJECT TERMS<br>FEAP User Guide<br>Blastox<br>lead-based paint   |  |   | 15. NUMBER OF PAGES<br>40                                 |
|   |  |   | 16. PRICE CODE  |
| 17. SECURITY CLASSIFICATION OF REPORT<br>Unclassified   | 18. SECURITY CLASSIFICATION OF THIS PAGE<br>Unclassified | 19. SECURITY CLASSIFICATION OF ABSTRACT<br>Unclassified | 20. LIMITATION OF ABSTRACT<br>SAR                         |

## Foreword

This study was conducted for the U.S. Army Corps of Engineers, Directorate of Military Programs (CEMP), Installation Support Division, under the Facilities Engineering Applications Program; Work Unit M3-FE3, "Deleading of Wooden Structures and Building Components," and Work Units FEAP-M3-F83 and FEAP-FM-F74, "Deleading of Elevated Steel Water Tanks." The technical monitors were Charles Racine and Malcolm McLeod, CEMP-RI.

The work was performed by the Materials and Structures Branch (CF-M) of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). Mark Slaughter is Chief, CF-M, and L. Michael Golish is Chief, CF. The CERL technical editor was William J. Wolfe, Information Technology Laboratory.

The Director of CERL is Dr. Michael J. O'Connor.

# Contents

|          |   |    |
|----------|---|----|
| <b>1</b> | <b>Executive Summary</b>  | 5  |
|          | Background  |    |
|          | Points of Contact   |    |
| <b>2</b> | <b>Pre-Acquisition</b>  | 8  |
|          | Description of the Technology   |    |
|          | Cost and Benefit Analysis   |    |
| <b>3</b> | <b>Procurement/Acquisition</b>  | 13 |
|          | Potential Funding Sources   |    |
|          | Technology Components and Sources   |    |
|          | Procurement Documents   |    |
|          | Procurement Scheduling  |    |
| <b>4</b> | <b>Post-Acquisition</b>   | 16 |
|          | Acquisition Scheduling  |    |
|          | Sampling  |    |
|          | Testing   |    |
|          | Service/Support Requirements  |    |
|          | Beneficial Reuse  |    |
|          | <b>Appendix A: Blastox® Suppliers</b>   | 19 |
|          | <b>Appendix B: Material Safety Data Sheet for Blastox®</b>                        | 21 |
|          | <b>Appendix C: FEAP Ad Flyer</b>  | 27 |
|          | <b>Appendix D: Sample Statement of Work for Removal of Exterior LBP From Wood</b> | 31 |
|          | <b>Appendix E: Sample Statement of Work for Removal of LBP From Steel</b>         | 35 |
|          | <b>Distribution</b>   |    |

# 1 Executive Summary

## Background

The U.S. Army maintains a large inventory of buildings constructed before 1978, when the use of lead-based paint (LBP) was discontinued. The Army also owns over 300 elevated water storage tanks and hundreds of other steel structures (bridges, equipment, and buildings) that have been painted with red lead primers.

The likelihood that any particular building will contain LBP increases with the structure's age, a circumstance that complicates required maintenance or demolition of older buildings—the most likely candidates for such treatment. For example, in residential structures or other facilities where children are present, LBP must be removed where an LBP hazard cannot be successfully controlled through management-in-place techniques. Other buildings require paint removal during regular maintenance and repair or renovation activities. While the Department of Defense (DOD) has scheduled some of its older buildings for demolition and disposal, it has been unable to proceed with this needed action because of the higher costs associated with the disposal of LBP-painted building components.

Regardless of whether LBP has been applied to a substrate of steel or wood, LBP abatement and disposal is problematic. The U.S. Environmental Protection Agency (USEPA) Resource Conservation and Recovery Act (RCRA) classifies any waste that leaches 5 parts per million (ppm) or more of lead (as determined by the USEPA toxicity characteristic leaching procedure [TCLP] test) a *hazardous waste*, which requires special handling and disposal. Since the residual waste from LBP removal commonly falls into this category, the high costs of worker protection and waste disposal prohibit the use of traditional paint removal methods (chemical stripping and abrasive blasting) for removing LBP.

A recently developed proprietary product—Blastox<sup>®</sup>—consists of a material, which, its manufacturer's\* product literature claims, may be added at a 15 weight percent mixture to a typical abrasive medium (such as coal slag or silica sand) to create an “engineered abrasive” suitable for sand-blasting lead-coating systems from wood,

---

\*The TDJ Group, Inc., 760-A Industrial Dr., Cary, IL 60013, tel. 847/639-0499.

steel, or concrete surfaces. The manufacturer also maintains that the additive chemically stabilizes the lead in the residual waste and reduces its potential for the leaching of lead to less than 5 ppm, thereby rendering the waste product nonhazardous.

The U.S. Army Construction Engineering Research Laboratory (CERL) performed a laboratory and field evaluation of LBP removal using abrasive blast media combined with Blastox® as part of an engineered abrasive, which confirmed the feasibility of removing and stabilizing LBP in a one-step process. Abrasive blasting successfully removed the paint and the lead stabilizer immobilized the lead, allowing the waste to pass the EPA TCLP test.

Laboratory analyses showed Blastox® to be a calcium silicate-based material with stabilization mechanisms similar to those of Portland cement. Chemical substitution reactions and physical encapsulation of the waste are the two stabilization mechanisms that provide a matrix with excellent long-term stability characteristics. The process using the engineered abrasive performed well in field demonstrations on both wood and steel substrates. The use of a chemical stabilizer combined with an abrasive blast medium was found to be cost effective based on a hazardous waste disposal cost avoidance of \$0.12 to \$0.44/sq ft of abated surface for wood substrates and \$0.93 to \$3.06/sq ft for steel substrates.

## Points of Contact

Vincent F. Hock  
U.S. Army Engineer Research  
and Development Center  
Construction Engineering  
Research Laboratory (CERL)  
ATTN: CEERD-CF-M  
PO Box 9005  
Champaign, IL 61826-9005  
217/373-6753  
FAX: 217/373-6732  
e-mail: v-hock@cecer.army.mil

Malcolm McLeod  
U.S. Army Corps of Engineers  
ATTN: CEMP-RI  
20 Massachusetts Avenue, NW  
Washington, DC 20314-1000  
202/761-0206  
e-mail: malcolm.e.mcleod@usace.army.mil

Susan A. Drozdz  
U.S. Army Engineer Research  
and Development Center  
CERL  
ATTN: CEERD-CF-M  
PO Box 9005  
Champaign, IL 61826-9005  
217/373-6767  
FAX: 217/373-6732  
e-mail: s-drozdz@cecer.army.mil

Charles W. Racine  
U.S. Army Corps of Engineers  
ATTN: CEMP-EC  
20 Massachusetts Avenue, NW  
Washington, DC 20314-1000  
202/761-4351  
e-mail: charles.w.racine@usace.army.mil

## 2 Pre-Acquisition

### Description of the Technology

#### *Conventional Abrasive Blasting*

Abrasive blasting is a process in which abrasive particles, such as sand, steel shot, plastic beads, or coal slag are propelled at the structure's surface. The propelling medium is usually compressed air. Once the particles strike the surface, they abrade the paint from the substrate. (If the substrate is wood, the top layer of the substrate is also removed. The amount removed depends on the type of wood and its condition, type of abrasive, particle morphology, and air pressure.) The debris is usually collected on a tarpaulin placed on the ground. Once the paint is removed, the wood surface is sanded to the desired finish, then recoated. On steel substrates, the only restriction is that the surface must be primed following blasting to prevent flash rusting.

The advantages of abrasive blasting are that:

1. It completely removes all the LBP from the surface.
2. It has a fast removal rate (about 100-150 sq ft/hr on wood and steel surfaces).
3. The materials used for the process are inexpensive.

The disadvantages of abrasive blasting are that:

1. There is a large volume of waste created.
2. The waste is usually classified as hazardous and must be disposed of accordingly.
3. Containment structures are needed due to the significant amount of dust created.
4. The initial capital costs can be significant due to the equipment requirement.
5. It may destroy soft substrates and damage even hard ones.

### ***Blasting With Engineered Abrasives***

High production rates, good surface profile, and a surface amenable to subsequent surface coating can all be achieved through abrasive blasting with a variety of blasting media. To create an engineered abrasive, it is necessary to add a sulfate, silicate, or phosphate-based material to ordinary blasting media. The chemical additive and lead paint waste will then react to chemically stabilize the leachable lead.

In addition to the previously mentioned advantages, engineered abrasives can create waste that can be classified as nonhazardous, thus eliminating one major disadvantage of removing LBP with conventional abrasives. Other disadvantages are:

1. There is still a large volume of waste.
2. Containment structures are still required.
3. The initial capital costs are the same as conventional abrasives.
4. If used improperly, any abrasive may destroy the surface from which the paint is being removed.

### **Cost and Benefit Analysis**

A cost analysis of the use of Blastox® as an additive to blast media to stabilize LBP after removal was based on field data from actual test sites within the Army installation network. Further analysis based on life cycle costs for other applications may be useful, but this study is limited to determination of present value savings, i.e., in immediate real dollar terms. It should be noted that the addition of Blastox® increases the cost of blasting media, but that the additional cost is more than recovered by avoiding hazardous waste disposal costs.

The summary data presented in Tables 1 and 2 were derived from separate cost analyses of wood substrates and steel substrates where the LBP was removed using an engineered abrasive. There is a variation in the equipment required for the various structures (i.e., one story wood structures versus 100 ft elevated steel tanks), thereby affecting the contractor overhead and the amount of scaffolding required. Furthermore, both the amount of blast media per square foot and the rate of removal (sq ft/hr) vary depending on the type of substrate. Finally, the cost of Blastox® is affected by the recommended rate of mixture with conventional blast media, depending on the type substrate.

Cost factors presented in the tables are based on actual contractor costs and compared to actual government estimates from site-specific LBP abatement projects. Capital facilities refers to the capital investment in the technology (i.e., blast machines, nozzles, etc.). The labor figures include the manpower for larger elevated structures and the associated scaffolding and dust containment. Consumables refers to the blast media, tarpaulins and covers, and packaging required for disposal. Environmental testing refers to required tests such as air monitoring (both personal and site), x-ray diffraction (XRF) testing, and TCLP analysis of the waste.

A determination of actual costs in terms of square foot savings must also include the stripping rate, i.e., the rate of paint removal in square feet abated per hour. Finally, the baseline disposal cost for the stabilized LBP waste is compared to the hazardous waste disposal cost (i.e., the cost to be avoided).

In summary, the data shown in Tables 1 and 2 shows an immediate and relevant savings for either type of substrate using the addition of Blastox® to the blast media. The hazardous waste disposal cost avoidance is \$0.12 to \$0.44/sq ft of abated surface for wood, and \$0.94 to \$3.06/sq ft for steel substrates.

Table 1. Savings in real present value dollars on wood substrates.

| Cost Factors  | Blast Media<br>Without Blastox®  | Blast Media<br>With Blastox® Additive<br>at \$0.25/lb (25% mixing)              |
|---|--|---|
| Capital facilities <sup>1</sup><br>Labor <sup>2</sup><br>Consumables <sup>3</sup><br>Environmental testing <sup>4</sup> | \$7.14/site hr<br>\$140.00/site hr<br>\$10.00/site hr<br>\$151.00            | \$7.14/site hr<br>\$140.00/site hr<br>\$17.20/site hr<br>\$151.00               |
| <b>Subtotal</b>   | <b>\$308.14/site hr</b>  | <b>\$315.34/site hr</b>   |
| Strip rate <sup>5</sup><br>Removal cost<br>Disposal cost <sup>6</sup>   | 100 sq ft/hr<br>\$3.08/sq ft<br>\$0.21 – \$0.54/sq ft<br>(\$350 – \$900/ton) | 100 sq ft/hr<br>\$3.15/sq ft<br>\$0.02 – \$.03/sq ft<br>(\$35.21 – \$55.01/ton) |
| <b>Total Cost<br/>Savings</b>   | <b>\$3.29 – \$3.62/sq ft</b>   | <b>\$3.17 – \$3.18/sq ft</b><br><b>\$0.12 – \$0.44/sq ft</b>                    |

Notes (Data Sources):

- 1 Capital rates of recovery are from actual contractor costs and DPW government cost estimate detail sheets. Costs for investment are amortized over 7 years for depreciation, and assume a 2000 hour site year.
- 2 Labor is quoted from actual contractor costs or derived from government estimate sheets.
- 3 Consumables are based on items used up in the job process. Blastox® is factored into this number based on its rate of application and percent of additive by weight. Abrasive blasting of wood required 1.2 lb of abrasive per sq ft of surface area blast cleaned. Abrasive blasting of steel required 8 lb of abrasive per sq ft.
- 4 Environmental testing includes air monitoring (both personal and site), XRF, and TCLP tests.
- 5 Strip rate varies depending on size of equipment and nature of the structure, i.e., wood buildings or 120-ft high elevated steel water or storage tank.
- 6 Disposal costs for hazardous waste were supplied by the Marketing Department, Chemical Waste Management, Inc., Oakbrook, IL. Costs for nonhazardous waste reflect typical costs from 12 states, as published in *Solid Waste Digest*, October 1993, Chartwell Information Publishers, Inc., Alexandria, VA., and supplementary information from 4 additional states. The higher end of the range of disposal costs reflects per unit costs of the disposal of small quantities of waste (less than 5 tons). Lower per-unit disposal costs reflect disposal of bulk wastes from larger projects. Most projects involving abrasive blasting of wood will generate less than 5 tons of waste.

**Table 2. Savings in real present value dollars on steel substrates.**

| Cost Factors   | Blast Media<br>Without Blastox®  | Blast Media<br>With Blastox® Additive<br>at \$0.25/lb (20% mixing)   |
|--|--|--|
| Capital facilities <sup>1</sup><br>Labor <sup>2</sup><br>Consumables <sup>3</sup>  | \$40.00/site hr<br>\$280.00/site hr<br>\$70.00/site hr (containment)<br>\$67.00/site hr (crane rental)<br>\$137.00/site hr<br>\$151.00           | \$40.00/site hr<br>\$280.00/site hr<br>\$102.00/site hr<br>\$67.00/site hr<br>\$169.00/site hr<br>\$151.00 |
| Environmental testing <sup>4</sup>   |  |  |
| <b>Subtotal</b>  | <b>\$608.00/site hr</b>  | <b>\$640.00/site hr</b>  |
| Strip rate <sup>5</sup><br>Removal cost<br>Disposal cost <sup>6</sup>  | 100 sq ft/hr (may be higher<br>when not hampered by height<br>and configuration)<br>\$6.08/sq ft<br>\$1.40 – \$3.60/sq ft<br>(\$350 – \$900/ton) | 100 sq ft/hr<br>\$6.40/sq ft<br>\$0.14 – \$0.22/sq ft<br>(\$35.21 – \$55.01/ton)                           |
| <b>Total Cost<br/>Savings</b>  | <b>\$7.48 – \$9.68/sq ft</b>   | <b>\$6.54 – \$6.62/sq ft</b><br><b>\$0.94 – \$3.06/sq ft</b>   |
| <b>Notes (Data Sources):</b>   |  |  |
| 1 Capital rates of recovery are from actual contractor costs and DPW government cost estimate detail sheets. Costs for investment are amortized over 7 years for depreciation, and assume a 2000 hour site year.   |  |  |
| 2 Labor is quoted from actual contractor costs or derived from government estimate sheets.   |  |  |
| 3 Consumables are based on items used up in the job process. Blastox® is factored into this number based on its rate of application and percent of additive by weight. Abrasive blasting of wood required 1.2 lb of abrasive per sq ft of surface area blast cleaned. Abrasive blasting of steel required 8 lb of abrasive per sq ft.  |  |  |
| 4 Environmental testing includes air monitoring (both personal and site), XRF, and TCLP tests.   |  |  |
| 5 Strip rate varies depending on size of equipment and nature of the structure, i.e., wood buildings or 120-ft high elevated steel water or storage tank.  |  |  |
| 6 Disposal costs for hazardous waste were supplied by the Marketing Department, Chemical Waste Management, Inc., Oakbrook, IL. Costs for nonhazardous waste reflect typical costs from 12 states, as published in <i>Solid Waste Digest</i> , October 1993, Chartwell Information Publishers, Inc., Alexandria, VA., and supplementary information from 4 additional states. The higher end of the range of disposal costs reflects per unit costs of the disposal of small quantities of waste (less than 5 tons). Lower per-unit disposal costs reflect disposal of bulk wastes from larger projects. Most projects involving abrasive blasting of wood will generate less than 5 tons of waste. |  |  |

## 3 Procurement/Acquisition

### Potential Funding Sources

U.S. Army installations can use Maintenance and Repair "K" account funds to procure the LBP waste chemical stabilizer as a blast media additive.

### Technology Components and Sources

Presently, the chemical stabilizer is commercially available with the desired specifications from several suppliers affiliated with the TDJ Group. See Appendix A for regional sources.

***The TDJ Group, Inc.***

760-A Industrial Drive  
Cary, IL 60013  
847/639-0499

### Procurement Documents

The following specifications need to be included in the procurement package for chemical stabilizers:

#### 1.0 Specifications

1.01 Blastox® is a tri-calcium silicate based material, the approximate composition of which is given in Table 3. (Appendix B contains the U.S. Occupational Safety and Health Administration [OSHA] Health Communication Material Safety Data Sheet [OSHA 29 CFR 1910/200] for the chemical stabilizer.)

1.02 It must be a calcium silicate material (a combination of tri- and di-calcium silicate) and contain no unoxidized iron or steel.

1.03 At least 95 percent of the material must be within the particle size range of greater than 60 mesh, but less than 12 mesh.

1.04 Its hardness must be greater than 6.0 on the Mohs scale.

1.05 It must have a bulk density of greater than 80, but less than 100 lb/cu ft.

1.06 It must not be a hazardous material under the OSHA Standard.

1.07 The chemical additive cannot create an additional workplace health hazard as defined by the OSHA Standard.

1.08 It must be approved for use without RCRA (or its state counterparts ) treatment permits by state environmental officials.

1.09 For lead abatement projects on wood surfaces, the blasting media must consist of at least 25 weight percent of the chemical additive.

1.10 For lead abatement projects on steel surfaces, the blasting media must consist of at least 20 weight percent of the chemical additive.

## 2.0 Operating Parameters

2.01 A pre-blended abrasive blast media is recommended for use on both wood and steel substrates.

2.02 The following operating parameters are recommended when using a chemically stabilized blast media to remove LBP on wood and steel surfaces:

Table 3. Composition of lead stabilizer.

| Compound                       | Weight Percent $\pm 5\%$ |
|--------------------------------|--------------------------|
| CaO                            | 65.52                    |
| SiO <sub>2</sub>               | 22.06                    |
| Al <sub>2</sub> O <sub>3</sub> | 4.58                     |
| MgO                            | 3.55                     |
| Fe <sub>2</sub> O <sub>3</sub> | 2.07                     |
| MnO                            | 0.44                     |
| K <sub>2</sub> O               | 0.4                      |
| SO <sub>3</sub>                | 0.27                     |
| TiO <sub>2</sub>               | 0.18                     |
| P <sub>2</sub> O <sub>5</sub>  | 0.11                     |
| Na <sub>2</sub> O              | 0.07                     |

| Parameter                              | LBP Removal on Wood | LBP Removal on Steel |
|--|---------------------|----------------------|
| Blast air pressure (psi)               | 90–100              | 100–120              |
| Average material usage rate (lb/sq ft) | 1.2                 | 6–10                 |
| Removal rates (sq ft/hr)               | 80–120              | 100–125              |

Appendix C of this User Guide includes a FEAP advertisement flyer that outlines this technology. Appendices D and E show sample “Statements of Work” for removal of exterior LBP from wood and steel, respectively, to help Army installation personnel create proper LBP abatement specifications.

### **Procurement Scheduling**

The lead time for ordering the chemical stabilizer additive is approximately 10 working days.

## 4 Post-Acquisition

### Acquisition Scheduling

The contractor shall submit the following plans to the Government Contracting Office before starting any LBP abatement work:

1. A written "Lead-Containing Paint Removal/Abatement Plan" shall be submitted for approval within 30 days after award of the purchase order.
2. A written "Worker Protection Plan" shall be submitted for approval within 40 days after award of the purchase order.
3. A written "Waste Collection Plan" shall be submitted for approval within 45 days after award of the purchase order.

### Sampling

To test this material properly, a homogeneous sample must be extracted from the mass of post-blasting debris. All the debris from the day (or specified period) of blasting must be collected in a pile on the tarpaulins placed on the ground. The post-blast Blastox® is smaller in size than the coal slag and paint chips and therefore may tend to settle through the pores of the waste material until it is near the bottom of the pile. With silica sand, the post-blasting particle size of the abrasive and chemical additive are about the same, eliminating the problem of separation while on the tarpaulin. A representative sample may be taken by "drilling" a hole from top to bottom of the pile in random locations and placing the sample in a bottle or bag for testing. It is recommended that at least three locations be sampled for testing a representative amount.

### Testing

Incongruities in testing are caused by laboratories differences in interpreting the test procedures and by human errors while performing the tests. To overcome some of these problems, and to prevent the waste from failing the test because of these errors, some measures should be taken to assure the material will pass all proper tests.

According to Section 6.1 of TCLP procedure, the sample should be taken out of the bag/bottle and re-homogenized by mixing. When this material is tested to determine which extraction fluid should be used (Section 7.1.4.1), the pH should be measured and recorded before adding the 3.5 mil of hydrochloric acid, according to Section 7.1.4.2 of the test. The final pH of the TCLP solution (after the sample has mixed 18 +/- 2 hr) should be tested, as well as the amount of calcium that leached into the solution. (This is done by the same procedure that determines the amount of lead in solution is tested.) If a sample should fail, these tests will help determine if the error was due to a sampling problem or a laboratory testing problem. In the past, samples using Blastox® have failed the TCLP test *only* as a consequence of an improper sampling procedure, or improper lab testing of the homogenous sample. When re-tested, the failed samples all passed as expected. Therefore, the final report delivered by the laboratory should contain the initial and final pH of the solution, and the amount of lead and calcium that leached into the solution.

## **Service/Support Requirements**

Once the paint has been removed, the wood surface must be sanded with an ordinary power sander to achieve the desired surface morphology. If the building is occupied, the inside must be monitored and cleaned properly.

## **Beneficial Reuse**

Even though stability data indicates long-term compliance, many generators are hesitant to landfill any material. The TDJ Group, Inc., has been working on markets for the spent abrasive other than landfills. As an alternative to landfilling the waste, sand-blast waste enriched with Blastox may be reused as a raw material for manufacturing processes in several areas of manufacturing. Currently, TDJ is recycling spent waste through several kilns and cement operations. The spent material is used as feedstock for the making of Portland cement at the kilns, and can be used to make flowable fill, a controlled low-strength concrete material. The cement operation may provide a letter documenting the transfer of ownership of the waste for liability purposes.

The process of beneficial reuse must be approved by each state agency, or the controlling EPA region. That approval has been obtained in the states where reuse facilities are operating, and should be easier to gain approval in new states as other states participate in the program. As long as the spent material is nonhazardous under the TCLP test (or STLC [Soluble Threshold Limit Concentration] test in

California), the waste may qualify for beneficial reuse. TCLP results and total metal results must be forwarded to the chosen cement kiln operation, who will approve the transaction and accept the material with a proper bill of lading labeling the waste as "nonhazardous feedstock for the cement kiln." This option is already operational in many states, and may be soon operational in many areas of the country. This non-disposal alternative could eliminate any liability for the generator. Currently, parties interested in beneficial reuse of spent abrasive should contact:

The TDJ Group, Inc.  
ATTN: Robert Bruton  
760-A Industrial Drive  
Cary, IL 60013  
847/639-1113

TDJ can recommend the closest kiln or cement operation that can take the waste. Currently, the following cement operations can take the spent abrasive waste:

California Portland Cement Company  
c/o Levond Steel  
ATTN: Joseph Cordner  
PO Box 24846  
Los Angeles, CA 90094  
310-823-4453

LaForge Cement Company  
c/o Industrial Services Inc.  
ATTN: Kenneth Casten  
5400 W. Marginal Way SW  
Seattle, WA 98106  
206/937-8025

## **Appendix A: BLASTOX® Suppliers**

**\*\* Denotes distributor.**

## **Appendix B: Material Safety Data Sheet for Blastox®**

MATERIAL SAFETY DATA SHEET  
(OSHA 29 CFR 1910.1200)

SECTION I - IDENTITY

Supplier's Name & Address

The TDJ Group, Inc.  
760 Industrial Drive  
Unit A  
Cary, IL 60013

Information Telephone Number

(847) 639-1113

Date of Preparation

January 31, 1994

SECTION II - HAZARDOUS INGREDIENTS / IDENTITY INFORMATION

Common Name

Blastox™ Process Additive

Ingredients

Substances similar to the following are known to be present in the admixture:

|                                     |                   |
|-------------------------------------|-------------------|
| 3CaO.SiO <sub>2</sub>               | (CAS #12168-85-3) |
| 2CaO.SiO <sub>2</sub>               | (CAS #10034-77-2) |
| 3CaO.Al <sub>2</sub> O <sub>3</sub> | (CAS #12042-78-3) |

Small amounts of CaO, MgO, K<sub>2</sub>SO<sub>4</sub>, and Na<sub>2</sub>SO<sub>4</sub> may also be present.

### SECTION III - PHYSICAL / CHEMICAL CHARACTERISTICS

Solubility in Water - Slight (0.1 - 1.0%)  
Specific Gravity - 3.15 - 3.22  
Color - Black with no odor

The following properties are not applicable as Blastox™ admixture is a solid in granular form, i.e.,

|                |                  |
|----------------|------------------|
| Boiling Point  | Melting Point    |
| Vapor Pressure | Evaporation Rate |
| Vapor Density  |                  |

### SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Blastox™ admixture is noncombustible and not explosive.

### SECTION V - REACTIVITY DATA

Blastox™ admixture is stable.

Blastox™ admixture is not incompatible with other materials, will not decompose into hazardous by-products, and will not polymerize.

Keep Blastox™ admixture dry until used to treat in abrasive cleaning

### SECTION VI - HEALTH HAZARD DATA

ACGIH Threshold Limit Value (1988-1989): Total dust containing no asbestos and less than 1% silica - 10 mg/m<sup>3</sup>

OSHA PEL (Transitional): Total dust 50 million particles per cubic foot

OSHA PEL (Final): Total dust 10 mg/m<sup>3</sup>  
Respirable dust 5 mg/m<sup>3</sup>

**Effects of Overexposure:**

**Acute:** This material contains calcium silicates and calcium aluminates, ingredients often found in cement and cement-like materials. Calcium silicates and aluminates, especially as ingredients in mortar, slurries, or plastic concrete can dry the skin and may cause caustic burns. Direct contact with the eyes can cause irritation. Inhalation can irritate the upper respiratory system.

**Chronic:** Admixture and abrasive dusts can cause inflammation of the lining tissue of the nose and inflammation of the cornea. Hypersensitive individuals may develop an allergic dermatitus. (Admixture may contain trace [less than 0.05%] amounts of chromium salts or compounds including hexavalent chromium or other metals found to be hazardous or toxic in some chemical forms. These metals can be found in various cement and cement-like products and are mostly present as trace substitutions within the principal minerals.)

**Emergency First Aid Procedures:** Irrigate (flood) eyes immediately and repeatedly with clean water. Wash exposed skin areas with soap and water. Apply sterile dressings. If ingested, drink water. Consult a physician immediately.

**SECTION VII - PRECAUTIONS FOR SAFE HANDLING AND USE**

If Blastox™ admixture is spilled, it can be cleaned up by using dry methods that do not disperse dust into the air. Avoid breathing the dust. Emergency procedures are not required.

Blastox™ admixture, by itself, can be treated as a common waste for disposal or returned to the container for later use if it is not contaminated or wet.

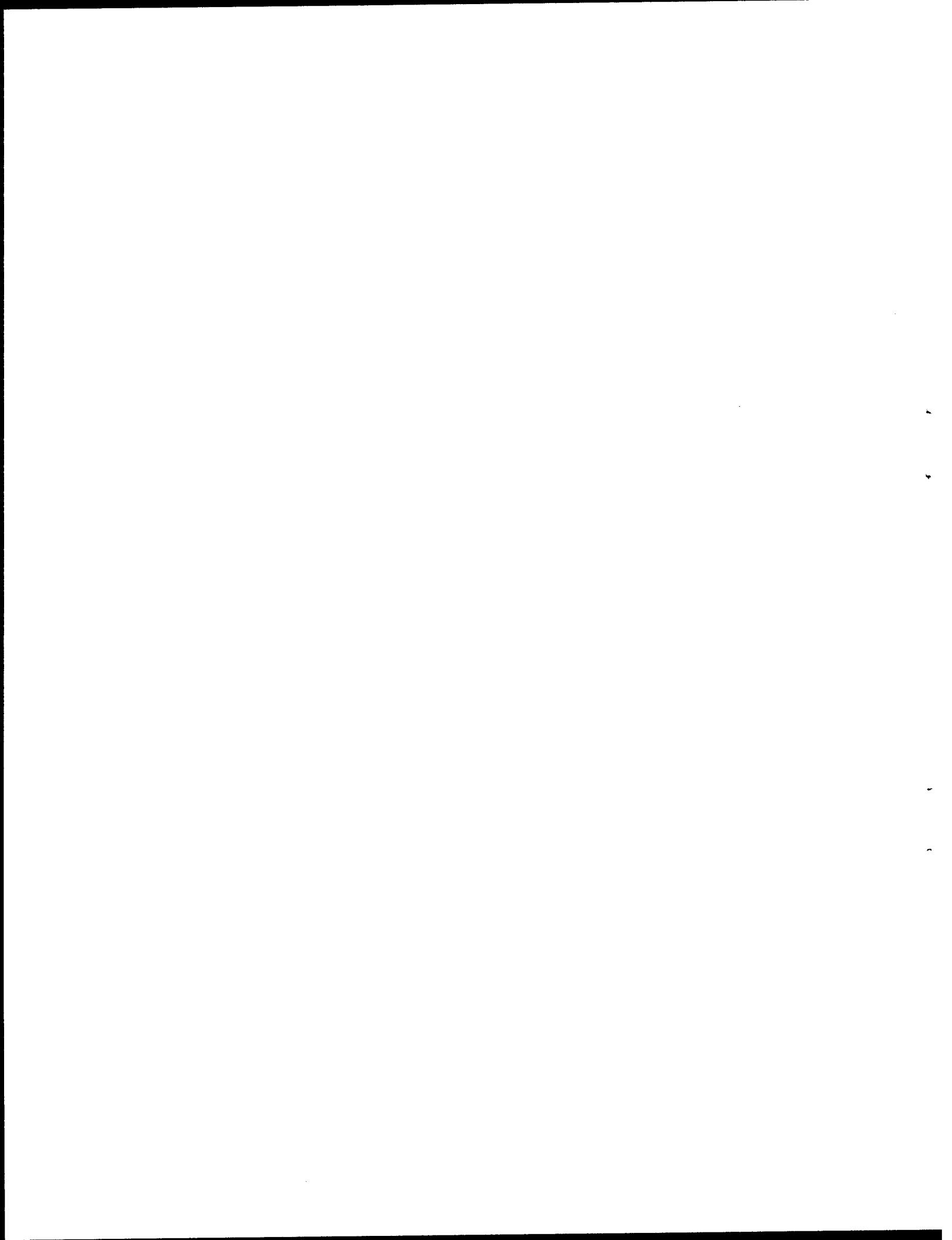
**SECTION VIII - CONTROL MEASURES**

In dusty environments, the use of an OSHA, MSHA, or NIOSH approved respirator and tight fitting goggles are recommended.

Local exhaust can be used, if necessary, to control airborne dust levels.

The use of barrier creams or imperious gloves, boots, and clothing to protect the skin from contact with wet Blastox™ admixture is recommended.

Following work with Blastox™ admixture, workers may wish to wash with soap and water.

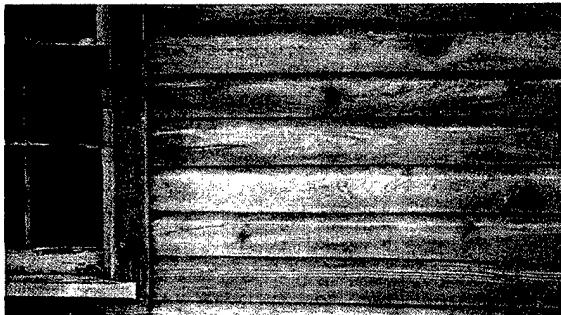


## **Appendix C: FEAP Ad Flyer**

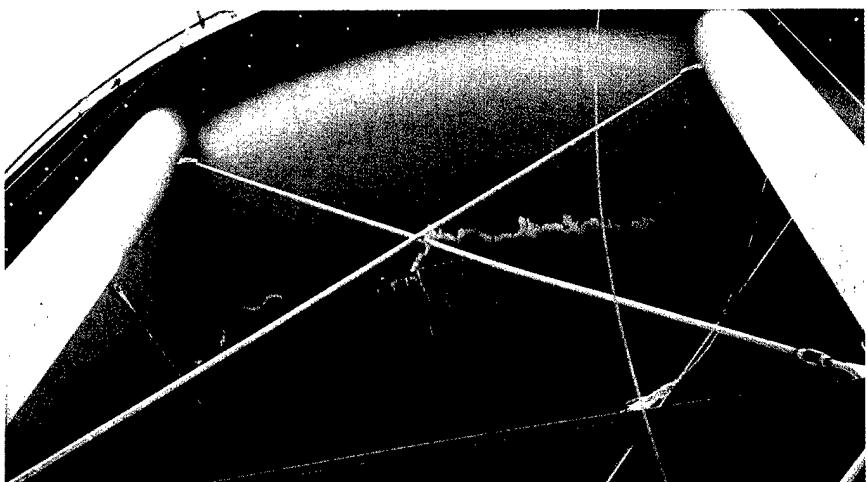
## Blast Media Additive for Lead-Based Paint Waste Stabilization



*Elevated steel water storage tank at Fort Meade had 8900 sq ft of lead-based paint removed with the blast media additive.*



*Up close: clean wood on the shed's siding (left) contrasts with peeling paint on the window frame (covered during removal). Steel water tank after partial cleaning—gray area shows no residual paint (below).*



### Stabilize Lead and Reduce Disposal Costs

**PROBLEM:** The danger of environmental contamination requires Army installations to dispose of lead-based paint blasting residue in expensive hazardous waste landfills.

**TECHNOLOGY:** A chemical stabilizer added to ordinary blasting media offers a safe, cost-effective method for lead paint abatement.

**DEMO SITES:** • Fort Meade, MD – FY93-94 • Fort Carson, CO – FY94 • Fort Hood, TX – FY94

**BENEFITS:** • Stabilizes lead paint and converts it to a reusable, nonhazardous waste  
• Lowers removal cost: \$3.15/sq ft for wood, \$6.40/sq ft for steel at Fort Meade  
• Avoids cost of hazardous waste disposal: maximum savings \$0.44/sq ft for wood,  
\$3.06/sq ft for steel at Fort Meade

# Renewable Blasting Waste Classifies as "Nonhazardous"

**T**he 1978 ban on lead-based paint (LBP) applied to residential structures, toys, furniture, and playground equipment. However, LBP continued to be used on water tanks, bridges, and other industrial structures until recently. In addition, much of the LBP used in residences before 1978 is still in place.

The U.S. Army maintains a large inventory of structures that potentially contain LBP, including buildings and steel water storage tanks. The older the structure, the more likely LBP will be found.

Facilities with LBP require paint removal during maintenance, repair or renovation. LBP also has to be removed when the hazard cannot be controlled successfully by management-in-place methods. In addition, many old buildings with LBP are slated for demolition and disposal.

The cost of stripping and disposing of waste LBP is prohibitive. Disposal in a hazardous waste landfill accounts for much of this cost.

To address this problem, the U.S. Army Construction Engineering Research Laboratories (USACERL) is investigating and developing new technologies for cost-effective LBP abatement. One method uses a granular chemical stabilizer called Blastox®, which is added to ordinary blast media. Blastox® is a calcium silicate-based material. A "stable" blasting waste is one that passes the EPA's Toxicity Characteristic Leaching Procedure (TCLP). Chemical substitution reactions and physical encapsulation of the waste are the two mechanisms that provide a matrix with excellent long term stability. The waste can also be reused in cement manufacturing.

## FEAP Demos and Results

The blast media additive was demonstrated under FEAP on four facilities: an unoccupied generator shed at Fort Meade, MD; an elevated steel water storage tank, also at Fort Meade; a family housing unit at Fort Hood, TX; and a concrete block building at Fort Carson, CO. At each site, the LBP was completely removed by abrasively blasting the wood, steel, or concrete structures with a combination of coal slag and Blastox®.

The waste generated from these operations was tested using both the TCLP and the EPA's Multiple Extraction Procedure (MEP). The MEP simulates long term stability in an acid rain environment (>1000 years). In both tests, the waste was found to leach less than 5 parts per million lead. Levels less than 5 ppm are classified as nonhazardous according to EPA's criteria, meaning the waste does not have to be disposed of in a hazardous waste landfill.

## Cost and Benefits

The cost of paint removal at each test site, including labor and materials, averaged \$3.15/sq ft of painted surface for wood and \$6.40/sq ft for steel. The steel tank's elevation added to the cost. Disposing of the stabilized, nonhazardous abrasive blast waste saves \$0.12 to \$0.44/sq ft for wood surfaces and \$0.93 to \$3.06/sq ft for steel substrates.

At Fort Meade, paint removal from a 1200-sq ft shed cost about \$3.15/sq ft compared to \$8/sq ft for chemical stripping, for a savings of \$5820. Additional savings are realized through the lower cost of disposing a nonhazardous waste. Disposal costs for a hazardous waste range from \$0.21 to \$0.54/sq ft compared to a nonhazardous waste cost of \$0.02 to \$0.03/sq ft.

Abrasive blast waste from the 8900-sq ft steel water storage tank also was taken to a nonhazardous waste landfill. In the case of steel, the cost of disposing a hazardous waste is about \$1.40 to \$3.60/sq ft compared to \$0.14 to \$0.22/sq ft for a nonhazardous waste.

Since the FEAP demonstrations, the manufacturer has been making arrangements in various parts of the nation for beneficial reuse of the waste. Some companies accept the waste for use in cement kilns as a feedstock in manufacturing Portland cement. The cost is comparable to disposal in a regular landfill.

## Procurement

Vendors for the blast media additive are listed in USACERL's *User Guide and Specifications for Lead Abatement Via Abrasive Blasting With a Chemical Stabilizer*. The product used in the demonstration is produced by TDJ Group, Cary, IL. Details of the FEAP demonstrations will be published in a USACERL Technical Report scheduled for release in 1995.

## Points of Contact

**T**o Vincent Hock or Susan Drozdz, USACERL, PO Box 9005, Champaign, IL 61826-9005, COMM 217-373-6753 or 217-352-6511 ext. 7427, or toll-free 800-USA-CERL.

**T**o Chuck Racine or Malcolm McLeod, U.S. Army Center for Public Works (CPW), 7701 Telegraph Road, Alexandria, VA 22310, COMM 703-806-5025 or -5196.



## **Appendix D: Sample Statement of Work for Removal of Exterior LBP From Wood**

**CEGS 02090 LEAD-BASED PAINT (LBP) ABATEMENT AND DISPOSAL**

A suitable contract scope of work for using the engineered abrasive technology on buildings and related structures can be prepared from CEGS 02090 "LEAD-BASED PAINT (LBP) ABATEMENT AND DISPOSAL" by adding the following paragraphs.

Under 1.18 EQUIPMENT AND MATERIALS, add the following:

**1.18.10 Engineered Abrasive**

The composition of the engineered abrasive shall be as follows:

For removal of lead-based paint from steel surfaces, the chemical stabilizer shall be incorporated into the abrasive blast medium (coal slag, copper slag, silica sand, or other traditional abrasive medium) at a rate of 20%, by weight.

For removal of lead-based paint from wood surfaces, the chemical stabilizer shall be incorporated into the abrasive blast medium (coal slag, copper slag, silica sand, or other traditional abrasive medium) at a rate of 25%, by weight.

The stabilizer is a tri-calcium silicate based material, the approximate composition of which is as follows:

| Compound                       | Weight % ( $\pm 5\%$ ) |
|--------------------------------|------------------------|
| CaO                            | 65.52                  |
| SiO <sub>2</sub>               | 22.06                  |
| Al <sub>2</sub> O <sub>3</sub> | 4.58                   |
| MgO                            | 3.55                   |
| Fe <sub>2</sub> O <sub>3</sub> | 2.07                   |
| MnO                            | 0.44                   |
| K <sub>2</sub> O               | 0.4                    |
| SO <sub>3</sub>                | 0.27                   |
| TiO <sub>2</sub>               | 0.18                   |
| P <sub>2</sub> O <sub>5</sub>  | 0.11                   |
| Na <sub>2</sub> O              | 0.07                   |

Solubility in Water – Slight (0.1 – 1.0%)  
Specific Gravity – 3.15 – 3.22  
Bulk Density 85 to 90 lb/cu ft  
Color – Black  
Odor – None  
Noncombustible  
Not Explosive  
Hardness – greater than 6.0 on the Mohs scale

Screen Analysis

| Sieve Size | % Retained |
|------------|------------|
| 16         | 28         |
| 20         | 24         |
| 30         | 20         |
| 40         | 16         |
| 50         | 10         |
| <50        | 2          |

Under 1.19 STORAGE OF MATERIALS, add the following:

1.19.1 Engineered Abrasive

Material must be kept dry until preparations are made for field application.

Under 3.3 LBP ABATEMENT METHODS, add the following:

3.3.11 Abrasive Blasting with an Engineered Abrasive

LBP shall be removed from [ ] by abrasive blasting techniques with an engineered abrasive. Work shall be performed in a LBP control area using negative pressure full containment with HEPA filtered exhaust. Paint residue shall be handled in accordance with the Hazardous Waste Management Plan. For dry blasting operations, moisture separators are required.

Under 3.4.4 Waste Sampling and Testing, add the following:

In addition, the following procedure shall be used to collect representative samples of the spent engineered abrasive for waste classification: Place a 5-

gallon sample of the waste onto a hard, flat surface and mix thoroughly with a shovel. Divide the pile into four quarters with the shovel. A subsample shall be taken from each quarter and combined as a single sample.

Under 3.6.6 Disposal, add the following:

**3.6.6.4 Spent Engineered Abrasive**

Prior to disposal, spent engineered abrasive shall be mixed with water to initiate the chemical stabilization reaction for the lead. Water shall be added at a rate of 1 part water for every 2 parts of chemical stabilizer, and thoroughly mixed.

## **Appendix E: Sample Statement of Work for Removal of LBP From Steel**

**CEGS 09965 PAINTING: HYDRAULIC STRUCTURES**

A suitable contract scope of work for using the engineered abrasive technology on steel structures such as water storage tanks and civil works structures can be prepared from CEGS 09965 "PAINTING: HYDRAULIC STRUCTURES" by adding the following paragraphs.

Under PART 1 GENERAL, add the following:

Under 1.5 SUBMITTALS, add the following language to the requirement for a Waste Classification, Handling, and Disposal Plan:

g. Collect representative samples of the spent engineered abrasive for waste classification as follows: Place a 5-gallon sample of the waste onto a hard, flat surface and mix thoroughly with a shovel. Divide the pile into four quarters with the shovel. A subsample shall be taken from each quarter and combined as a single sample.

h. Prior to disposal, spent engineered abrasive shall be mixed with water to initiate the chemical stabilization reaction for the lead. Water shall be added at a rate of 1 part water for every 2 parts of chemical stabilizer, and thoroughly mixed.

Add new paragraph:

**1.12 STORAGE OF ENGINEERED ABRASIVE**

Material must be kept dry until preparations are made for field application.

Under PART 2 PRODUCTS, add the following:

**2.5 Engineered Abrasive**

The composition of the engineered abrasive shall be as follows:

For removal of lead-based paint from steel surfaces, the chemical stabilizer shall be incorporated into the abrasive blast medium (coal slag, copper slag, silica sand, or other traditional abrasive medium) at a rate of 20%, by weight.

The chemical stabilizer is a tri-calcium silicate based material, the approximate composition of which is as follows:

| Compound                       | Weight % ( $\pm 5\%$ ) |
|--------------------------------|------------------------|
| CaO                            | 65.52                  |
| SiO <sub>2</sub>               | 22.06                  |
| Al <sub>2</sub> O <sub>3</sub> | 4.58                   |
| MgO                            | 3.55                   |
| Fe <sub>2</sub> O <sub>3</sub> | 2.07                   |
| MnO                            | 0.44                   |
| K <sub>2</sub> O               | 0.4                    |
| SO <sub>3</sub>                | 0.27                   |
| TiO <sub>2</sub>               | 0.18                   |
| P <sub>2</sub> O <sub>5</sub>  | 0.11                   |
| Na <sub>2</sub> O              | 0.07                   |

Solubility in Water – Slight (0.1 – 1.0%)

Specific Gravity – 3.15 – 3.22

Bulk Density 85 to 90 lb/cu ft

Color – Black

Odor – None

Noncombustible

Not Explosive

Hardness – greater than 6.0 on the Mohs scale

#### Screen Analysis

| Sieve Size | % Retained |
|------------|------------|
| 16         | 28         |
| 20         | 24         |
| 30         | 20         |
| 40         | 16         |
| 50         | 10         |
| <50        | 2          |

Under 3.1 CLEANING AND PREPARATION OF SURFACES TO BE PAINTED, add the following:

**3.1.7 Lead Paint Removal by Abrasive Blasting with an Engineered Abrasive**

Surfaces bearing lead-based paint shall be prepared as specified in Paragraph 3.1.1. Abrasive media shall be an engineered abrasive containing 20 weight percent of chemical stabilizer.

## DISTRIBUTION

|  |   |   |
|--|---|---|
| Chief of Engineers<br>ATTN: CEHEC-IM-LH (2)                                  | FORSCOM<br>Forts Gillem & McPherson 30330<br>ATTN: FCEN   | Linda Hall Library<br>ATTN: Receiving 64110-2498  |
| ATTN: HECSA Mailroom (2)   | Installations: (20)   | USEPA Region V<br>ATTN: AFRC-ENIOL-FE 60561   |
| ATTN: CECG   | TRADOC<br>Fort Monroe 23651<br>ATTN: ATBO-G   | Defense Nuclear Agency<br>ATTN: NADS 20305  |
| ATTN: CECC-P   | Installations: (19)   | Defense Logistics Agency<br>ATTN: MMDIS 22060-6221  |
| ATTN: CECC-R   | Fort Belvoir 22060<br>ATTN: CETEC-IM-T<br>ATTN: Water Resources Support Ctr   | National Guard Bureau 20310<br>ATTN: NGB-ARI  |
| ATTN: CECW   | USA Natick RD&E Center 01760<br>ATTN: STRNC-DT<br>ATTN: AMSSC-S-IMI   | US Military Academy 10996<br>ATTN: MAEN-A<br>ATTN: Facilities Engineer<br>ATTN: Geography & Envir Engrg |
| ATTN: CECW-O   | US Army Materials Tech Lab<br>ATTN: SLCMT-DPW 02172   | Naval Facilities Engr Command<br>ATTN: Facilities Engr Command (8)                                      |
| ATTN: CECW-P   | USARPAC 96858<br>ATTN: DPW<br>ATTN: APEN-A  | ATTN: Division Offices (11)   |
| ATTN: CECW-PR  | SHAPE 09705<br>ATTN: Infrastructure Branch LANDA  | ATTN: Public Works Center (8)   |
| ATTN: CEMP   | Area Engineer, AEDC-Area Office<br>Arnold Air Force Station, TN 37389   | ATTN: Naval Constr Battalion Ctr 93043  |
| ATTN: CEMP-E   | HQ USEUCOM 09128<br>ATTN: EC4J-LIE  | ATTN: Naval Facilities Engr Service Center 93043-4328   |
| ATTN: CEMP-C   | CEWES 39180<br>ATTN: Library  | 416th Engineer Command 60623<br>ATTN: Gibson USAR Ctr   |
| ATTN: CEMP-M   | CECRL 03755<br>ATTN: Library  | US Army MEDCOM<br>ATTN: MCFA 78234-6000   |
| ATTN: CEMP-R   | USA AMCOM<br>ATTN: Facilities Engr 21719<br>ATTN: AMSMC-EH 61299<br>ATTN: Facilities Engr (3) 85613                                       | Fort Detrick 21702-5000<br>ATTN: MCHS-IS  |
| ATTN: CERD-C   | USAARMC 40121<br>ATTN: ATZIC-EHA  | Fort Sam Houston 78234-5000<br>ATTN: MCA-PW   |
| ATTN: CERD-ZA  | Military Traffic Mgmt Command<br>ATTN: MTEA-GB-EHP 07002  | Walter Reed Army Medical Ctr 20007-5001<br>ATTN: MCHL-PW  |
| ATTN: CERD-L   | ATTN: MT-LOF 20315<br>ATTN: MTE-SU-FE 28461<br>ATTN: MTW-IE 94626   | Tyndall AFB 32403<br>ATTN: HQAFCESA/CES<br>ATTN: Engrg & Srvc Lab                                       |
| ATTN: CERD-M (2)   | Fort Leonard Wood 65473<br>ATTN: ATSE-DAC-LB (3)<br>ATTN: ATZT<br>ATTN: ATSE-CFLO<br>ATTN: ATSE-DAC-FL<br>ATTN: Australian Liaison Office | USA TSARCOM 63120<br>ATTN: STSAS-F  |
| ACS(IM) 22060<br>ATTN: DAIM-FDP  | Military Dist of WASH<br>Fort McNair<br>ATTN: ANEN 20319  | American Public Works Assoc. 64104-1806   |
| CE Installation Support Div. 22310-3862<br>ATTN: CEISD-ES (2)                | USA Engr Activity, Capital Area<br>ATTN: Library 22211  | US Army CHPPM<br>ATTN: MCHB-DE 21010  |
| ATTN: CEISD-E  | US Army ARDEC 07806-5000<br>ATTN: AMSTA-AR-IMC  | US Gov't Printing Office 20401<br>ATTN: Rec Sec/Deposit Sec (2)   |
| ATTN: CEISD-FT   |   | Nat'l Institute of Standards & Tech<br>ATTN: Library 20899  |
| ATTN: CEISD-ZC   |   | Defense General Supply Center<br>ATTN: DGSC-WI 23297-5000   |
| US Army Engr District<br>ATTN: Library (40)                                  |   | Defense Supply Center Columbus<br>ATTN: DSCC-WI 43216-5000  |
| US Army Engr Division<br>ATTN: Library (7)                                   |   | Defense Tech Info Center 22060-6218<br>ATTN: DTIC-O (2)   |
| US Army Transatlantic Program Center<br>ATTN: TAC 22604<br>ATTN: TAE 09096   |   | 239<br>11/99  |
| US Army Engineering and Support Ctr<br>ATTN: CEHND 35807-4301                |   |   |
| SETAF<br>ATTN: AESE-EN-D 09613<br>ATTN: AESE-EN 09630                        |   |   |
| Supreme Allied Command<br>ATTN: ACSGEB 09703<br>ATTN: SHIHB/ENGR 09705       |   |   |
| INSCOM<br>ATTN: IALOG-I 22060<br>ATTN: IAV-DPW 22186                         |   |   |
| USA TACOM 48397-5000<br>ATTN: AMSTA-XE                                       |   |   |
| Defense Distribution Region East<br>ATTN: ASCE-WI 17070-5001                 |   |   |
| Defense Distribution Region West<br>ATTN: ASCW-WG 95296-0100                 |   |   |
| HQ XVIII Airborne Corps 28307<br>ATTN: AFZA-DPW-EE                           |   |   |
| US Army Materiel Command (AMC)<br>Alexandria, VA 22333-0001<br>ATTN: AMCEN-F |   |   |
| Installations: (20)  |   |   |